§ 23. Detection of Time Evolution of Magnetic Island by Magnetic Measurement in LHD

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In LHD experiment, it is observed that the magnetic island grows during a discharge[1]. The existence and the width of the magnetic island are estimated by the flattening of the profile of the electron temperature measured by Thomson scattering. By this method, the profile is obtained at only the crossing line between the poloidal cross-section and equatorial plane and the time sampling rate depends on the pulse (10Hz or 50Hz) of YAG laser. Furthermore, in case the small magnetic island is filled by plasma, the profile does not show the flattening. Then it is impossible to identify the existence of the island. The growth of the island is accompanied by the perturbed magnetic field b^{r}_{pl}. The island full normalized width w is given by[1]

$$w^2 = w^2_{ex} + C(b^{r}_{pl}/B_t) \qquad (1)$$

Here, w_{ex}, C and B_t are the width of the magnetic island in vacuum field, a constant coefficient and the toroidal field, respectively. The time evolution of the width of island can be detected directly by measuring of the field b^{r}_{pl}. The time scale and amplitude of the b^{r}_{pl}/B_t is so long and weak (few seconds and few gauss at O-point of island) that the magnetic loop with large cross section is needed to detect b^{r}_{pl}.

The flux loops are equipped at 3-O and 8-O port in LHD to measure the magnetic flux Φ^R which in corresponding to b^{r}_{pl}(Fig.1). The total area of each loops is around 12[m^2]. These loops are π[rad] away from each other. The loop at 3-O port is three - dimensional and the other loop is plane structure. The calibration to remove the effect from the mutual induced field of the helical coil current, poloidal coil current and plasma current is carried out. This enables us to measure the magnetic field originated from only plasma.

The time evolution of w and Φ^R are shown in Fig2(a)(b). The w in Fig.2(a)is the width of island estimated from the flattening of the electron temperature profile. The flattening does not appear in the temperature profile before t=0.8[s]. The width w increases from 90[mm] to 180[mm] within 1.6[s]. Figure2(b) shows Φ^R at 3-O(solid) and 8-O(dashed). Φ^R starts increasing its amplitude at t=0.7[s]. The relationship between w^2 and Φ^R/B_t is shown in Fig.2(c). The solid line means the linear fitting of Eq.(1). This shows that the w_{ex} is estimated about 9[cm]. This is corresponding to the width of the magnetic island created by LID coil beforehand.

It is confirmed that the magnetic measurement of the time evolution of the magnetic island is possible. More loops will be equipped to detect the 3-D structure of the magnetic island. Consequently, it will be possible to study the self-healing phenomena.

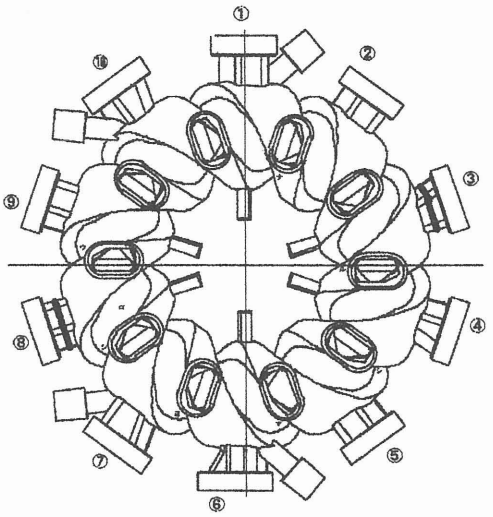

Fig. 1: Magnetic loop equipped on LHD. Magnetic loops are equipped at 3-O and 8-O port (bold lines).

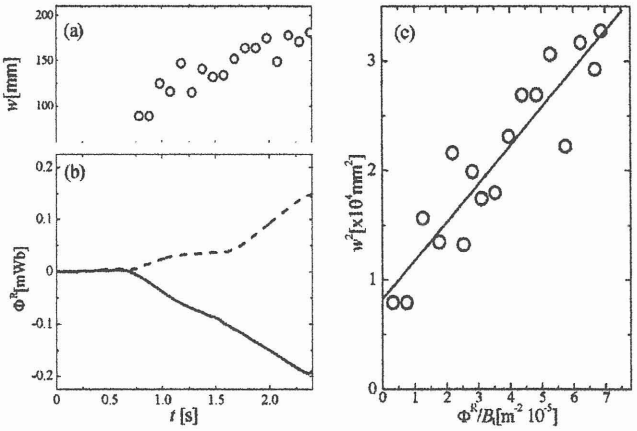

Fig. 2: Time evolution of (a)island width defined from the flattening of the electron temperature profile, (b)radial flux at 3-O port(solid) and 8-O(dashed), respectively.

References

1) N. Ohyabu *et al* Phys. Rev. Lett. 88, 055005 (2002)